THERMAL ECOLOGY OF THE DUNE SAGEBRUSH LIZARD,

SCELOPORUS ARENICOLUS

An Undergraduate Research Scholars Thesis

by

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ABSTRACT

Thermal Ecology of the Dune Sagebrush Lizard, *Sceloporus arenicolus*

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Sceloporus arenicolus is a habitat specialist that depends on shinnery oak sand dune blowouts. Populations of *S. arenicolus* (Dune Sagebrush Lizard) have decreased in areas fragmented from roads built during oil development in the Permian Basin. The ability of these habitat specialists to survive depends, in part, on thermally favorable microclimates in dune blowouts. Activity of *S. arenicolus* is restricted by temperature during periods of the day in which there are no available microhabitats with preferable temperatures. We hypothesized that lizard activity may be more constrained in degraded areas, if the thermal environment becomes less favorable for activity. By comparing activity restriction times, we determined that while there is little difference between fragmented and unfragmented habitats overall, there are differences in the microhabitats. This study shows that habitat fragmentation by road development in the dune systems differentially affects microhabitats and homogenizes the landscape, and is possibly one of the mechanisms driving population declines in those sites.

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SECTION I

INTRODUCTION

The Dune Sage Brush Lizard (*Sceloporus arenicolus*) populations have decreased in areas fragmented from roads built during oil development in the Permian Basin. (Leavitt and Fitzgerald 2013, Smolensky and Fitzgerald, 2011). *S. arenicolus* is a quintessential habitat specialist, found only within shinnery oak (*Quercus havardi*) sand dune systems (Degenhardt et al., 1996). Here the lizards reside on the edge of the shinnery oak in what are called dune blowouts. The blowouts are large wind-blown depressions of sand surrounded by shinnery-covered dunes, and provide an intricate thermal environment that the lizards depend on for survival.

As with most reptiles, many aspects of *S. arenicolus*' physiological performance are greatly dependent on its body temperature (T_b) (Cowels and Bogert, 1944). A body temperature too low or too high reduces the lizard's digestive rate, growth rate and metabolism, as well as the ability to forage and escape predation (Huey 1982, Dawson 1975, Bennett, 1980). Due to these thermal constraints, lizards seek to maintain their body temperature within a species-specific range that allows for optimal performance, known as the thermal performance breadth. As ectotherms, they maintain their T_b mainly through their behavior and the environment (Brattstrom, 1965, Heath, 1965, Heatwole, 1970). However, during the course of the day, there are thermally unfavorable periods in which the lizards must retreat to a thermal refuge; these are quantified as hours of restriction (h_r) (Sinervo et al., 2011).

While Sinervo's research has shown alterations in h_r to be a strong predictor of population declines within a habitat, as high h_r levels results in less time that the lizards have to actively forage, this study looks at an entire habitat or landscape as a whole and does not consider the varied microhabitats available to the lizard. When taken into account, microhabitats create a much more heterogeneous thermal landscape that allows lizards to expand their activity time (Buttemer and Dawson, 1993). These microhabitats, which can be less than a meter in size, have microclimates that are determined by numerous factors such as substrate, vegetation coverage and wind exposure. *S. arenicolus'* survival depends, in part on its ability to preferentially select microhabitats with environmental operative temperatures that allow them to achieve body temperatures that are close to their preferred temperature for optimal performance: 23-38°C. *Sceloporus arenicolus* has been shown to select microhabitat sites that are relatively cool, and avoid the hot, South-facing, slopes (Fitzgerald et al., 1997).

Several studies have shown that fragmentation in forests due to road construction has had adverse effects on microclimate conditions (Murica, 1995). In these cases, fragmentation increased the air temperature and solar radiation in remnant patches (Tuff et al., 2016). Similar fragmentation in the dune systems degrades the habitat by reducing the size of the dunes in which S. *arenicolus* reside, thus potentially resulting in higher temperatures and altered restriction times in fragmented habitats of *S. arenicolus*. The cumulative effect may contribute to the population declines in these areas.

In determining how landscape fragmentation impacts the thermal environment for this species we asked two central questions. Specifically, is there a difference in the potential for daily activity between fragmented and unfragmented sites? Is there a difference in operative temperature at the scale of microhabitat? We predicted that fragmented habitat would have more h_r than unfragmented habitat and that there would be significant variation in h_r within sites of fragmented habitat.

We used copper lizard models to measure the operative temperature of the lizards in various microhabitats in both fragmented and unfragmented landscapes. Operative temperature, (T_o) is the equilibrium temperature of an animal, ultimately determined by various sources of radiation and temperature, and gives a detailed measure of the temperature as experienced by the lizard. We compared differences in the hours of restriction between fragmented and unfragmented sites as well as differences in operative temperature at the scale of microhabitat.

SECTION II

METHODS

We used an adaption of the copper lizard models to measure the operative temperature of S. *arenicolus* as outlined by Bakken (1992). Instead of electroplating a clay model to match the exact physiology of the lizard or using a copper tube to obtain approximate, and likely inaccurate measures of temperature, we used copper foil to form an intermediate likeness of the lizard. The models were made using 36 gauge copper foil, cut using a single stencil to ensure uniformity. Four 0.635 cm holes were punched into the torso, for later insertion of legs, and then formed around a 1.27 cm dowel rod and sealed with an epoxy. The tail was formed and sealed around another equally sized dowel rod that was shaved into a conical form approximating the shape of and adult male lizard. The other end of the dowel rod was carved into trapezoidal wedge shape that closely approximated the lizards head and was used a mold to fold the copper models head around and then be sealed shut. At this point the model consisted of a sealed empty copper tube with four holes in the torso, closely approximating the anatomical features of *S. arenicolus*. The legs were crafted using 0.635 cm copper tubing that was cut and bent to represent the resting leg positions of *S. arenicolus*. The legs were then inserted into the copper model body and the ends of the legs were pinched off to close the hole and created a small foot like bend at the end.

The data loggers were inserted by making a small slit in what would be the copper models' "cloaca". The tip of the temperature probe was wrapped several times in a small strip of duct tape to insulate it from the copper and insure an accurate internal reading. These copper lizards were then painted and calibrated against a live individual to insure that the models matched their live counterparts within 1°C. HOBO v2 External Data loggers were used to monitor and log the models temperature.

A total of 24 models were constructed and set out at 3 separate localities where *S. arenicolus* is currently known to exist: Maljimar, New Mexico, Andrews County, Texas and Winkler County, Texas. The models were set out in sets of 10 at 4 fragmented and 4 unfragmented sites for periods of 5-7 days. Each blowout studied had one pair of models in each cardinal direction at the edge of the shinnery oak and the open sand. One of the pair would be placed underneath the shinnery cover and the other would be placed 10-50 cm downslope in the open sand. The final two models were placed at the bottom of the sand blow out, again with one placed in available shade and the other in direct sunlight. All of the models were set facing North/South to prevent any variation in the sun exposure.

We computed h_r as times between sunrise and sunset (approximated at 07:00 and 22:00) at which the temperature recorded by the operative temperature models was not within the lizards' active temperature range (23-38°C). The average h_r for each of the microhabitats (North, South, East, West dune slopes and bottom of the blowout) was computed and compared to each other and between fragmented and unfragmented habitats using a student's t-test. The average h_r for all fragmented sites was also calculated and compared to the unfragmented sites using a student's t-test.

SECTION III

RESULTS

The mean h_r for unfragmented habitat was 8.06 hours (Figure 1) and the mean h_r for fragmented habitat was 8.31 hours (Figure 2) with a difference of 15 minutes. Overall they were not different statistically (t-test, $p=0.43$). The differences in microhabitats were more apparent. The East-facing slope's mean h_r was 7.32 and 8.32 for unfragmented and fragmented habitat respectively. This was a difference in an hour of activity time. The West-facing slope's average h_r in unfragmented habitat was 7.97 and 8.2 for fragmented with a difference equaling 14 minutes. The h_r for the bottom of the blowout was 22 minutes higher for fragmented sites (h_r= 8.42) than it was for unfragmented sites (h_r=8.52). The North-facing slope's h_r was 8.52 in unfragmented sites and 8.58 in fragmented sites with a difference of 4 minutes. The South-facing slope was the only slope that unfragmented sites (h_r=8.45) had higher h_r than fragmented sites (h_r=8.03) with a difference of 25 minutes. None of the microhabitats were significantly different between sites (t-test, $p>>.05$)

Figure 1.

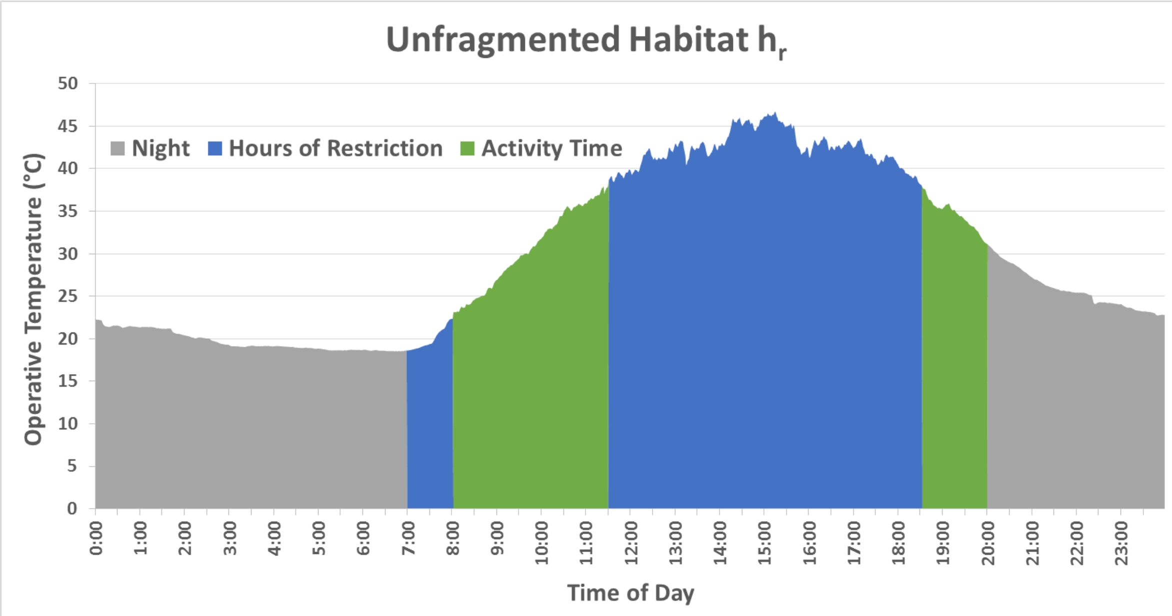

Figure 1. Unfragmented Habitat h_r. Average temperature and hours of restriction for all unfragmented sites. h_r= 8.06

Figure 2.

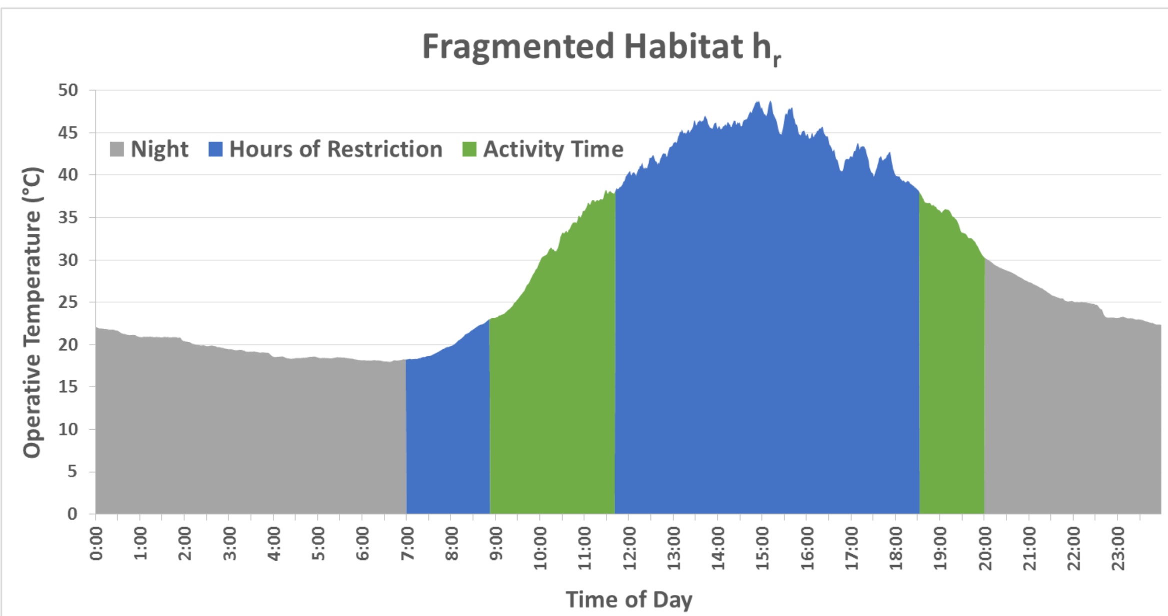

Figure 2. Fragmented Habitat h_r. Average temperature and hours of restriction for all Fragmented sites. h_r= 8.31

SECTION IV

CONCLUSION

Our results make sense in the framework of much of the previous research on habitat selection in this species. *Sceloporus arenicolus* prefers large interconnected dune blowouts (Fitzgerald et al., 1997). Fragmentation degrades the bumpy topography of the dunes and differentially affects microhabitats. Degradation of blowout areas appears to make the landscape hotter in preferred microhabitats, as the h_r of East, West, and Blowout were higher in fragmented habitat. As the sun rises in the East and sets in the West, these slopes will have periods where they are shaded by the dune either in the morning or evening. The decreased size of the blowouts would result in longer sun exposure and higher temperatures to these sites.

The minimal difference in h_r between fragmented and unfragmented sites on North and South-facing slopes also makes sense in this context. Due to their direction, no dunes will cast a shadow reducing sun exposure on the North and South-facing slopes throughout the day. Dune degradation from fragmentation therefore has little effect on the North and South-facing slopes, which were the least thermally favorable, having the highest overall h_r.

While we did not find differences in the overall average h_r among fragmented and unfragmented sites, averaging at this scale may mask important differences that impact lizard activity and behavior. Even though our data did not prove to be statistically significant, this was likely due to our small sample size (n=8), and the obvious differences in our measurements of microhabitats indicated there may be important differences across the thermal landscape in fragmented and unfragmented areas. These differences may be one mechanism that limits carrying capacity and dispersal of *S. arenicolus* in fragmented areas.

The next step is to combine the operative temperature data with precise dynamic elevation maps in a GIS to create operative temperature landscapes as determined by Sears and Colleagues (2011). An operative temperature landscape will give a detailed view of the portions of the habitat that are thermally available for lizard activity throughout the day and season. This line of research will provide greater insight into how landscape condition affects thermal ecology of this habitat specialist and further our understanding of population dynamics within dune systems. We hope that this project and its continuation will aid in the conservation of the species.

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